Exercise 1. Convex Lens

Using the lens-maker's equation:

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Find the focal length of a convex sapphire lens with refractive index 1.75 if the two radii are 0.3 [cm] and 0.5 [cm].

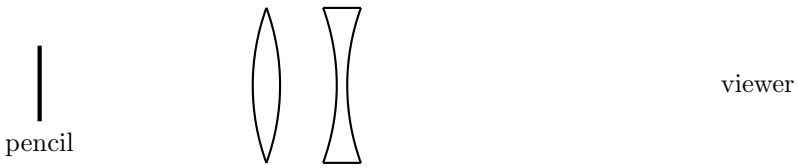
Hint: for a convex lens, we should have $f > 0$.

Exercise 2. Concave Lens

Find the focal length of a concave sapphire lens with refractive index 1.75 if the two radii are 0.3 [cm] and 0.5 [cm].

Hint: for a concave lens, we should have $f < 0$.

Exercise 3. Thin Lenses I

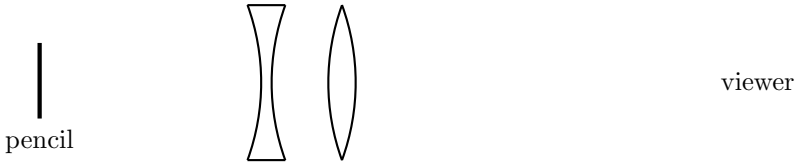


Consider a short pencil with height a 5 [cm] located 10 [cm] to the left of two thin lenses (the thin lenses from are the lenses from exercise 1 and 2). Where and at what size does a viewer 20 [cm] to the right of the lenses see the pencil if the lenses are treated in the thin lens approximation?

Hint: in the thin lens approximation

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \dots \frac{1}{f_n}; \qquad \frac{1}{d} + \frac{1}{d'} = \frac{1}{f}; \qquad \frac{s'}{d'} = -\frac{s}{d}$$

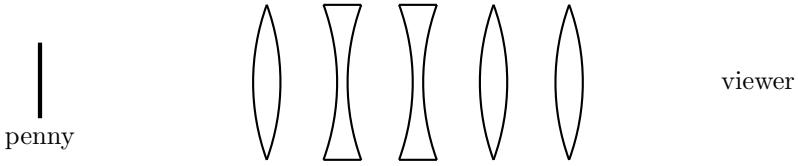
Exercise 4. Thin Lenses II



Consider a short pencil with height a 5 [cm] located 10 [cm] to the left of two thin lenses (the thin lenses from are the lenses from exercise 1 and 2). Where and at what size does a viewer 20 [cm] to the right of the lenses see the pencil if the lenses are treated in the thin lens approximation?

Exercise 5. Thin Lenses III

Consider the following configuration of thin lenses:



If a penny of radius 1 [cm] is placed 3 [cm] to the left of the configuration of lenses, at what position, with what height, and at what magnification does an observer on the right see the penny? Assume that all lenses have focal lengths of ± 2 [cm].

Exercise 6. Separated Lenses I

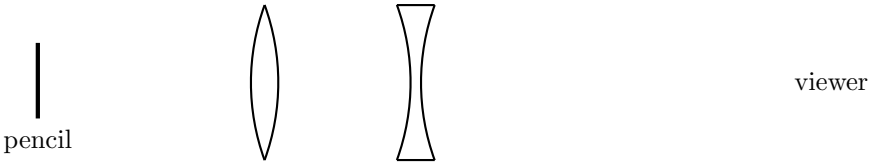
If two lenses are no longer close together, but instead separated by a distance a, then their collective focal length is modified to become:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{a}{f_1 f_2}$$

Find the focal length of the two lenses in exercises 1 and 2 if they are separated by a distance of 4 [cm].

Exercise 7. Separated Lenses II

Continuing the last problem, if a 5 [cm] tall pencil is placed 10 [cm] to the left of the center of the two lens configuration, where and at what size does a viewer 20 [cm] to the right of the lenses see the pencil?



Exercise 8. Thick Lenses I

If a lens cannot be treated as thin, its thickness must be taken into account and this is done by modifying the lens-maker's equation to include a term proportional to the thickness, t, at the center of the lens:

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2} + \frac{n-1}{nR_1R_2}t\right)$$

Find the focal length of a convex sapphire lens with refractive index 1.75 if the two radii are 0.3 [cm] and 0.5 [cm] and the thickness in the center is 1 [cm].

Exercise 9. Thick Lenses II

Find the focal length of a concave sapphire lens with refractive index 1.75 if the two radii are 0.3 [cm] and 0.5 [cm] and the thickness in the center is 0.25 [cm].

Exercise 10. Camera Aperture

If an iPhone has a $F = 1.8$ lens and a focal length of $f = 4.25$ [mm], what is the aperture diameter a? Hint: $F = f/a$?